Problems of Urban Development and Growth

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The most conspicuous feature of world population growth is its accelerating rate, concentrating in urban areas. As cities increase in number, size, and functional complexity, they become focal points of environmental stress for many reasons:

(1) They consume resources in greater quantities and at faster rates. Can remote sensing reveal new water supplies? Timber sources? Mineral-related structures? Construction materials? Which sensors, which spectral bands, and what resolutions will be most useful?

(2) Cities encounter increasingly severe waste disposal problems in the air, in the water, and on land. Can remote sensing identify pollutants, locate their sources, and trace their dispersal? A report on the state-of-the-art of sensing of pollution has just been completed by the Geographic Applications Program for NASA, and publication is expected soon.

(3) Larger and larger areas are being devoted to transportation networks. Can remote sensors help to determine what new linkages will be needed? Can traffic flows be measured from aircraft or satellite platforms?

(4) Urban agglomerations become dependent upon more distant sources of food. Can we measure urban encroachment on farmlands, and locate new ones or help to intensify the production of old ones?

(5) Cities concentrate people in hazard zones. Can remote sensors help to identify faults and aid in earthquake research? Warn of storms and floods? Identify potential landslide and cave-in areas?

(6) In cities, economic and social problems are intensified as the result of competitive demands by pressure groups for incompatible uses of available space. Can remote sensors provide background data to help policy makers and administrators reach more logical or justifiable decisions?

The answer to all of these questions is a qualified yes. Remote sensing technology can help, but quantified requirements are needed to improve the state-of-the-art, and we will consider current capabilities and future aspirations at the workshop session later.

Two very important problems involved in urban analysis and planning are:

(1) The rapidity of land use and functional change, coupled with delays in obtaining pertinent data promptly by means of traditional techniques

(2) Differences in definition and categorization of urban land uses from place to place, coupled with differences among local studies in time, scale, and purpose

To help solve those problems, the Geographic Applications Program of the U.S. Geological Survey, in close cooperation with NASA, has focused a large part of its effort upon urban change detection and the preparation of an Atlas of Urban and Regional Change, to obtain a national overview of urban conditions, and to measure the environmental impact of urban growth and internal functional changes.

In spite of early settlement of the Chesapeake Bay area, and the function of the Bay as an important shipping lane, urbanization of its immediate fringe has lagged far behind the national average. In 1960, 70 percent of the population of the United States was urban, and samples of the still incomplete 1970 census returns indicate a substantial rise in that figure. In the 23 counties bordering the Chesapeake Bay only 25.8 percent of the population was urban in 1950; 29 percent in 1960; and 30.7 percent in 1970. Even so, one must recognize that the hinterland of the Chesapeake Bay provides targets for its shipping, markets for its fisheries, and sources of its pollution. That hinterland includes the southern third of the highly urbanized Northeastern urban corridor, commonly known as Megapolis, which extends

from Norfolk to Boston, and which is rapidly expanding inland from the coastal zone toward the headwaters of the principal rivers that are tributary to Chesapeake Bay.

The immediate hinterland contains one of more than a score of urban test sites (Washington, D.C.) currently under study to develop more effective methods for using remote sensing technology and data from high altitude aircraft and satellite platforms to measure, analyze, and predict urban changes and their environmental impact. The popularly known Census Cities Project of the U.S. Geological Survey's Geographic Applications Program is being conducted in cooperation with the Department of the Interior's Earth Resources Observation System (EROS) Program and NASA's Earth Resources Program.

Twenty-six cities, widely distributed over the United States, and representing urban communities of different sizes, shapes, growth rates, functions, and environmental settings, were selected for the experiment (see fig. 1). More than 20 of them were photographed with nine cameras from 50 000 feet above the surface by NASA overflight missions timed to coincide as closely as possible with the time the 1970 census of population was being taken.

Some significant problems in urban data acquisition have been revealed or clarified to date. Among them, are such problems as:

(1) Determination of the relative effectiveness, for different purposes, of different remote sensing systems, including the use of black-and-white, color, color infrared and multispectral films; radar, scanners, microwave, scatterometers, and other devices

(2) Development of information systems which are compatible with data sources, instrument capabilities, user needs, and cost effective procedures

(3) Creation of simplified models capable of receiving and using small-scale data effectively.

(4) Learning to use surrogate signatures to interpret specifics from what can be seen.

(5) Finding the real utility of remote sensor technology in urban transportation studies, in the extraction of housing and neighborhood quality data from aerial and satellite photography, in locating vacant housing, and in identifying intraurban relationships in complex urban regions.

As indicated earlier, one of the test sites for which remote sensing data are being applied to practical problems of urban planning and policy formation is the Washington, D.C., urbanized area. The U.S. Geological Survey is using data obtained from NASA and other sources, in cooperation with the Metropolitan Washington Council of Governments and the University of Iowa's Institute of Urban and Regional Research, to prepare a land use analysis of the District of Columbia and seven surrounding counties. Plate 1 shows the flight lines and area covered by overflight mission 128 on June 28, 1970, with an RB-57F aircraft at 50 000 feet above the terrain. There were three north-south flight strips, spaced about 18.5 kilometers (11 miles) apart. The diagram in the lower right corner shows the area covered by each of the cameras aboard the aircraft. The legend shows there were nine cameras.

Figure 2 is a diagram of the photos from nine sensors, for a central frame over the Washington test site. On the left are sample frames from three metric cameras, and on the right, sample frames from six Hasselblad cameras. The two RC-8s have a focal length of 6 inches, and produce an image scale of 1:100 000 at a flight altitude of 50 000 feet. One of these cameras has color infrared film with a minus-blue filter. The other camera has black-and-white panchromatic film used with the same filter. Each of the RC-8 photos covers a square about 14 miles on a side, or an area of some 200 square miles. Photographs were taken with 60 percent overlap in line of flight and about 30 percent sidelap between flight lines. This provides stereoscopic coverage and permits three-dimensional viewing. A Zeiss camera with a 12-inch focal-length lens takes pictures at a scale of 1:50 000 and covers a square about 7 miles on a side, or an area of nearly 50 square miles. This camera also is loaded with color infrared film but the lens is fitted with a "D" filter. With the Zeiss camera there is edge-to-edge coverage in the line of flight, but there is some gap in coverage between flight lines in some instances.

The Hasselblad cameras all use roll film, 70 millimeters wide. Three are loaded with black-and-white multispectral film, one with infrared color film and two with color film. Of the cameras with black-and-white panchromatic film, one has a green filter, one has a red filter, and the third contains black-and-white infrared film. These three cameras simulate television cameras which are scheduled to be aboard the ERTS-A platform. In the ERTS data handling systems these three different television images can be combined to form one false-color image. The composite image is represented by the fourth camera, which contains color infrared film and the same minus-blue filter used on the RC-8 cameras with color infrared film. The two cameras containing panchromatic color film have on one a stronger blue filter for

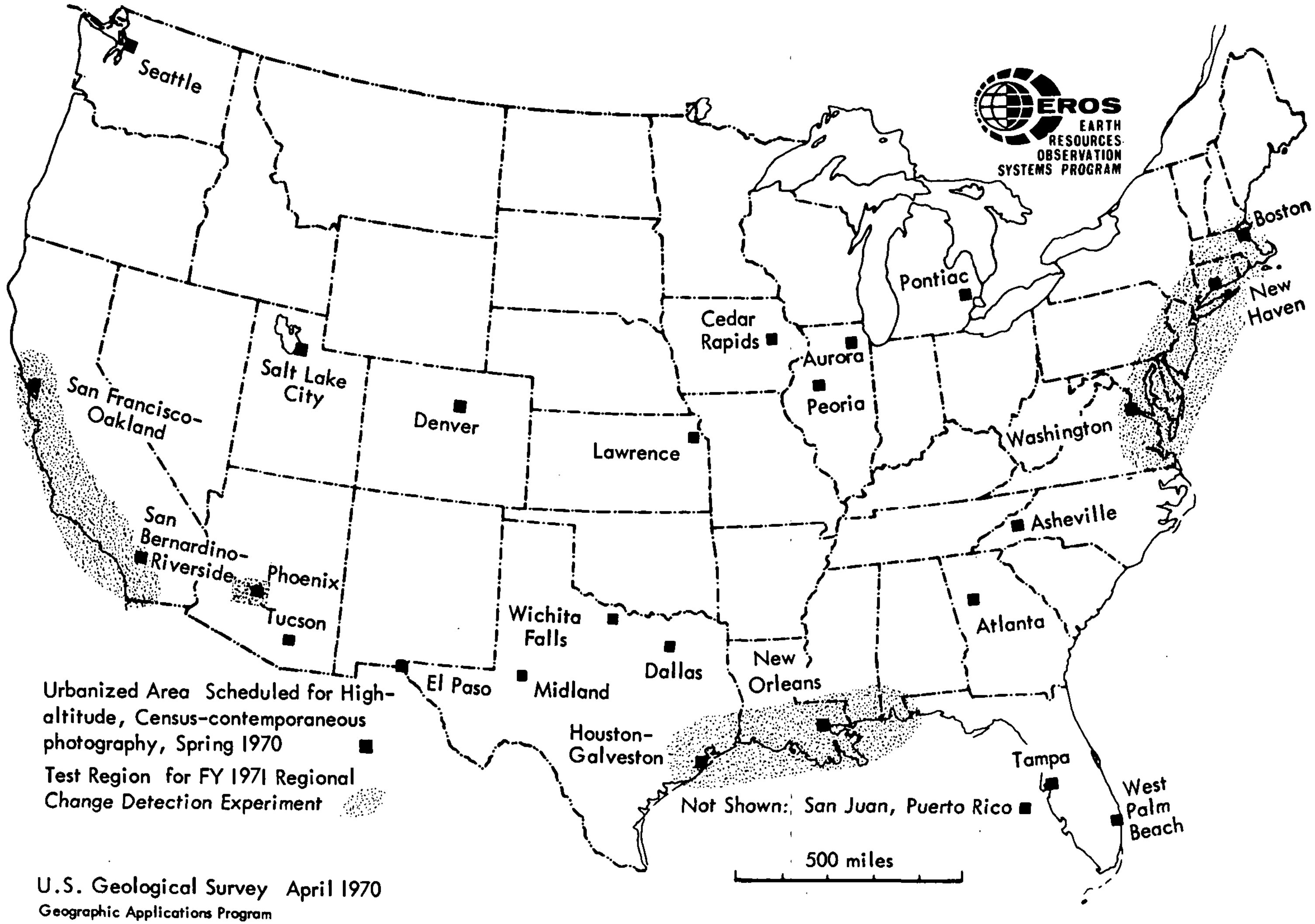

Figure 1.–Map showing urban and regional test sites.

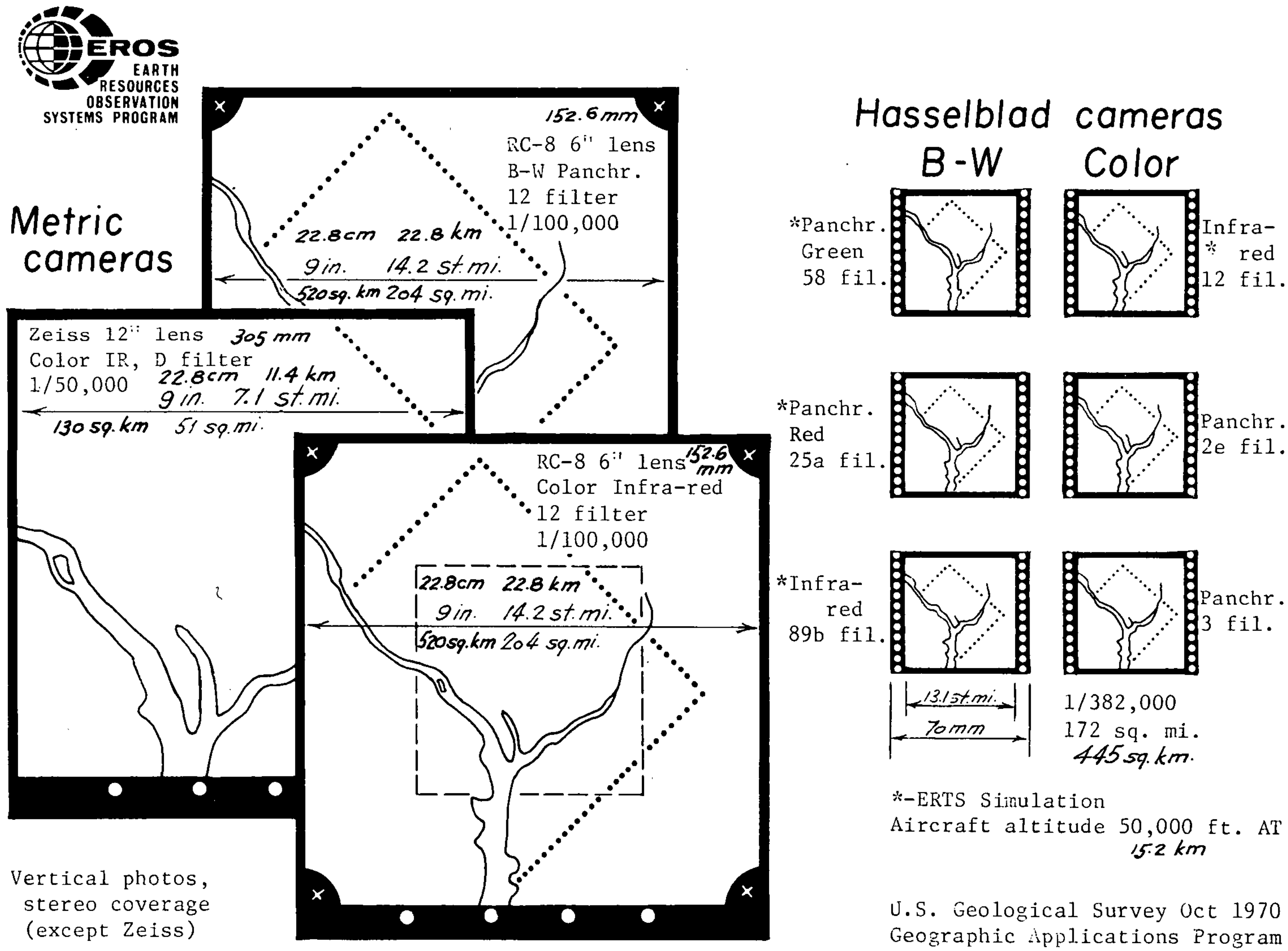

Figure 2.–Diagram of photo sensor set, one frame per camera, mission 128, Washington, D.C.

additional haze penetration, and on the other a no. 3 filter to render the scene about as would be seen through the camera sight at the time the picture was taken. Each of the Hasselblad cameras has a 40-millimeter focal length lens which covers about 175 square miles (slightly less than the RC-8 camera), producing an image scale of 1:382 000 from a flight altitude of 50 000 feet above terrain.

The first step in urban analysis is the preparation of a rectified photo mosaic, fitted with a rectangular coordinate grid. Figure 3 shows a portion of the mosaic of Washington, D.C. This portion is a simulated page for an Atlas of Urban and Regional Change. The grid interval is one kilometer. The publication format will have a mosaic square 20 X 20 kilometers at 1:100 000. This square is placed to the left of the center on a standard page used for computer printout (28 X 38 centimeters). The right hand panel provides legend space for overprints or overlays, or for extension of the map area. Pages may be bound at the top or at the left, or used singly, and folded into reports using the page size of conventional office stationery.

As in other experiments proposed for the Department of the Interior's Earth Resources Observation Systems (EROS) Program, the Universal Transverse Mercator projection and rectangular coordinate system is in use, and all distances and areas are expressed in metric units. Geographic coordinates and bar scales in non-metric units are also shown, however, and the various State coordinate systems can be indexed for users who require them.

The next step in the urban analysis is the preparation of an overlay showing the census statistical areas. A simulation of the census overlay is shown in figure 4. The fine solid lines in the figure represent the census tract boundaries. The numbers represent the census tract identifications. Supplementary overlays could show additional point and line features appearing on the mosaic, or essential to its interpretation.

The next step is the analysis of area features, especially land use. This is illustrated in plate 2, a simulated overlay or overprint for a portion of Washington, D.C. The land use interpretation is plotted directly on an overlay to the color infrared photography at 1:100 000. The smallest mapping unit is a square 0.2 kilometer on each side, or about 11 acres. This is not much larger than the area covered by the blunt end of the color pencil used in the image interpretation, but this minimum-sized mapping unit is larger than the anticipated resolution cells. The legend shows the nested land use classification system presently being tested in the prototype analysis of the Washington,D.C.,test site. There are eight urban classes and five nonurban classes. Three of the classes are repeated, so there are really only ten different categories. The urban and nonurban land use categories can be expanded or contracted according to the scale and minimum-size area for mapping purposes. Land ownership information garnered from ground truth may be shown on the supplementary overlay.

After mapping land use to the limits of the mosaic, a single boundary line is drawn around the central mass of urban land uses. This is taken as the boundary of the urban area at the time of the overflight. It becomes the definition that will form the basis for comparison with other urban areas similarly delimited, and for analyzing changes in one urban area at different times.

The next step in the analysis is to measure the area of land in each land use category and to report the totals by census tracts. The information for a particular time period is then stored in computer retrievable format. The land use overlays and area measurements for two different time periods will form the basis for change detection, and for analysis of location, kind, and intensity of change.

Hopefully, the remote sensing study of metropolitan Washington will be expanded next year to include the Baltimore area and the urban corridor between the two cities. The processing of data for the additional area will be similar to the procedures described above but the resultant product will have more specialized applications. In addition to the end products of the Washington Census City study described above, the Washington-Baltimore study will involve the creation of an automated data bank programmed to receive additional information from all available sources, including geology pertinent to the area, hydrology, soils, climatic conditions, population distribution and structure, transportation networks, recreational resources, and other data recommended by policy-making and planning organizations at the federal, regional, state, and local levels.

Not much has been said about urban regions, but, in closing, it is important to emphasize that an urban region can be defined differently for different environmental and human activity phenomena in an area. For example, the boundaries of an urban resources region might be very different from those of a labor supply region; the boundaries for a food resources region might differ significantly from those for industrial resources; and boundaries for transportation networks might be very different from those for recreational resources. How does one define those boundaries or

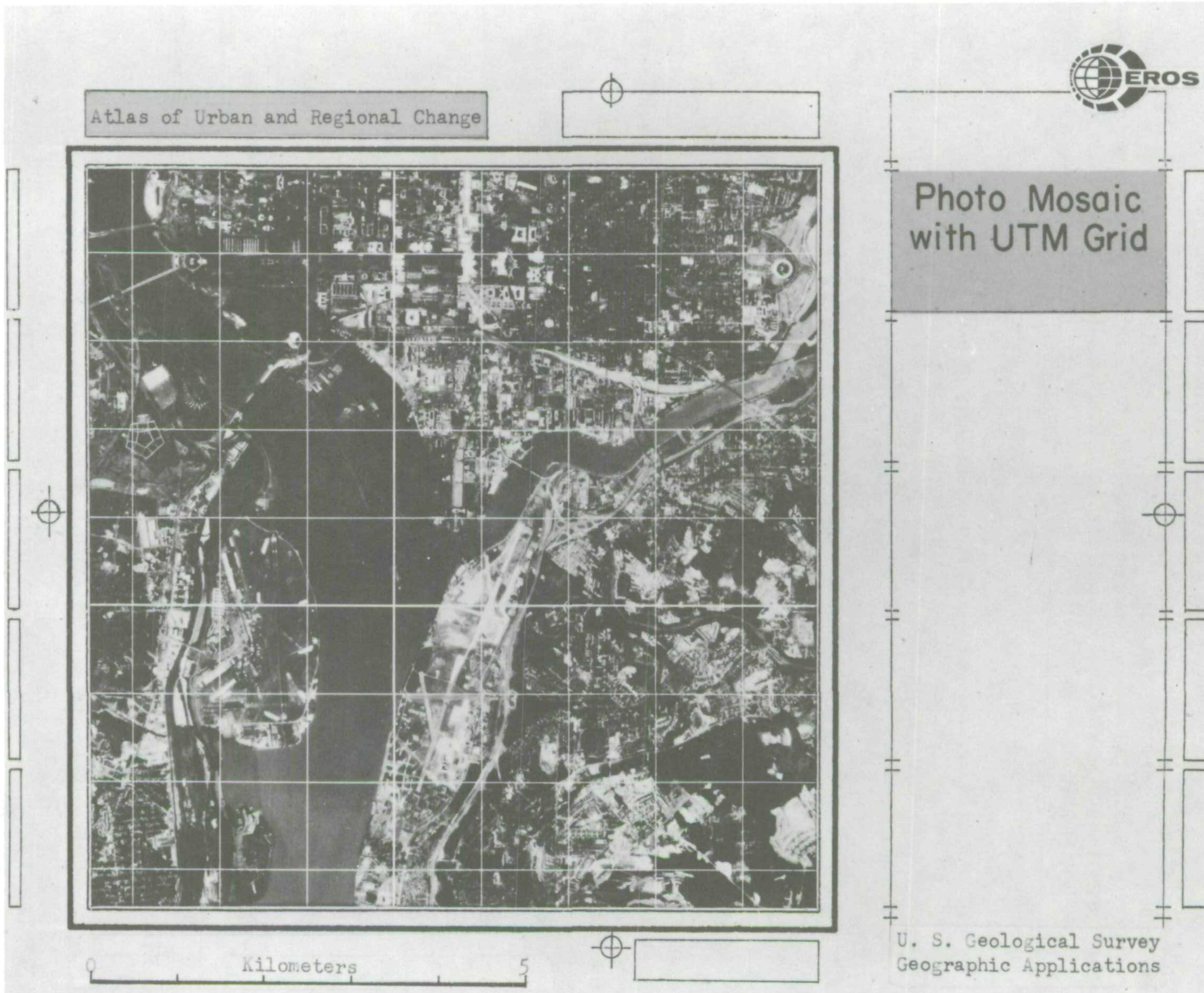

Figure 3.–Atlas of Urban and Regional Change, simulated page with gridded photo mosaic.

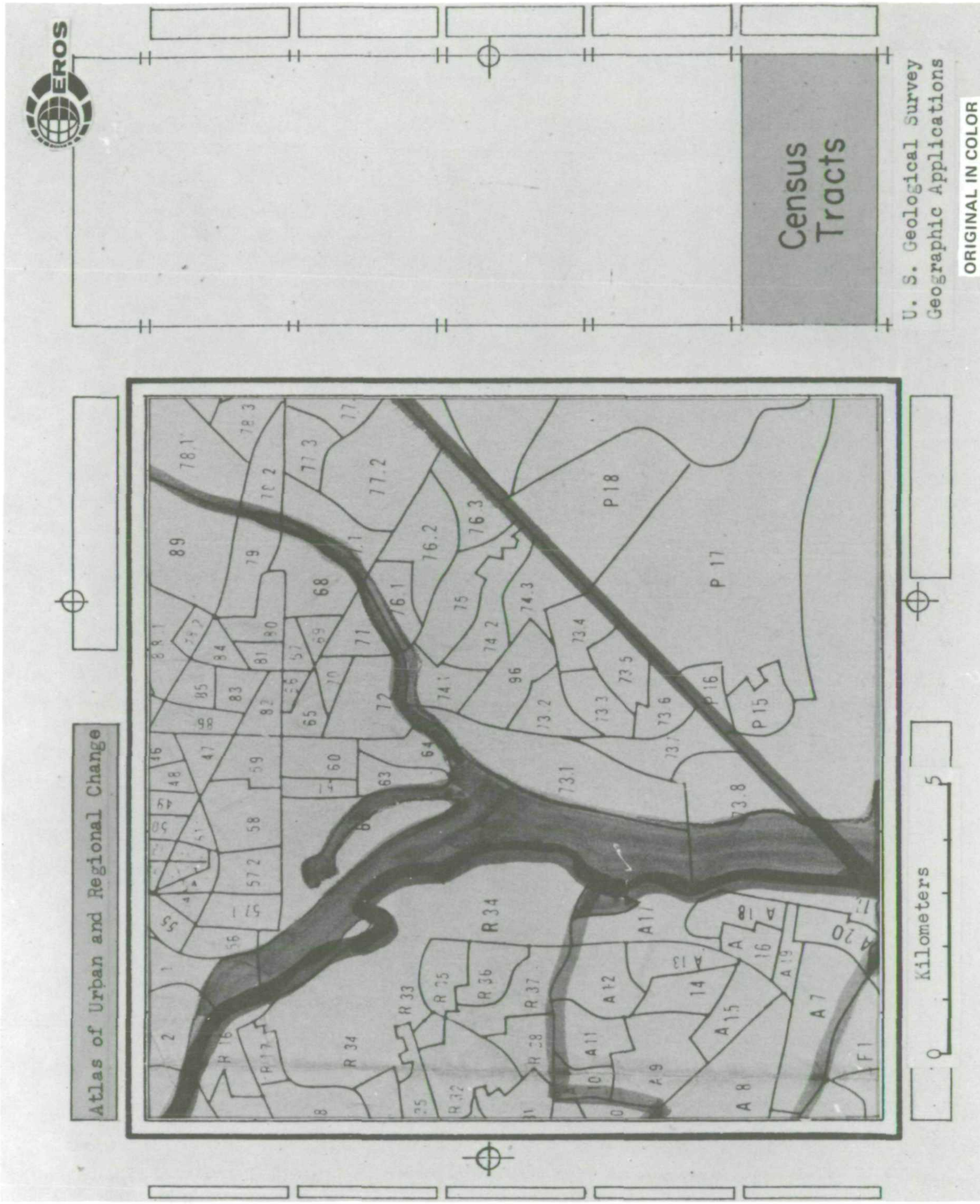

Figure 4.--Atlas of Urban and Regional Change, simulated page with census tract boundaries.

interfaces? Identify them? Measure their movements? Forecast their effects on neighboring cities? These problems and others will be discussed in the work group session.

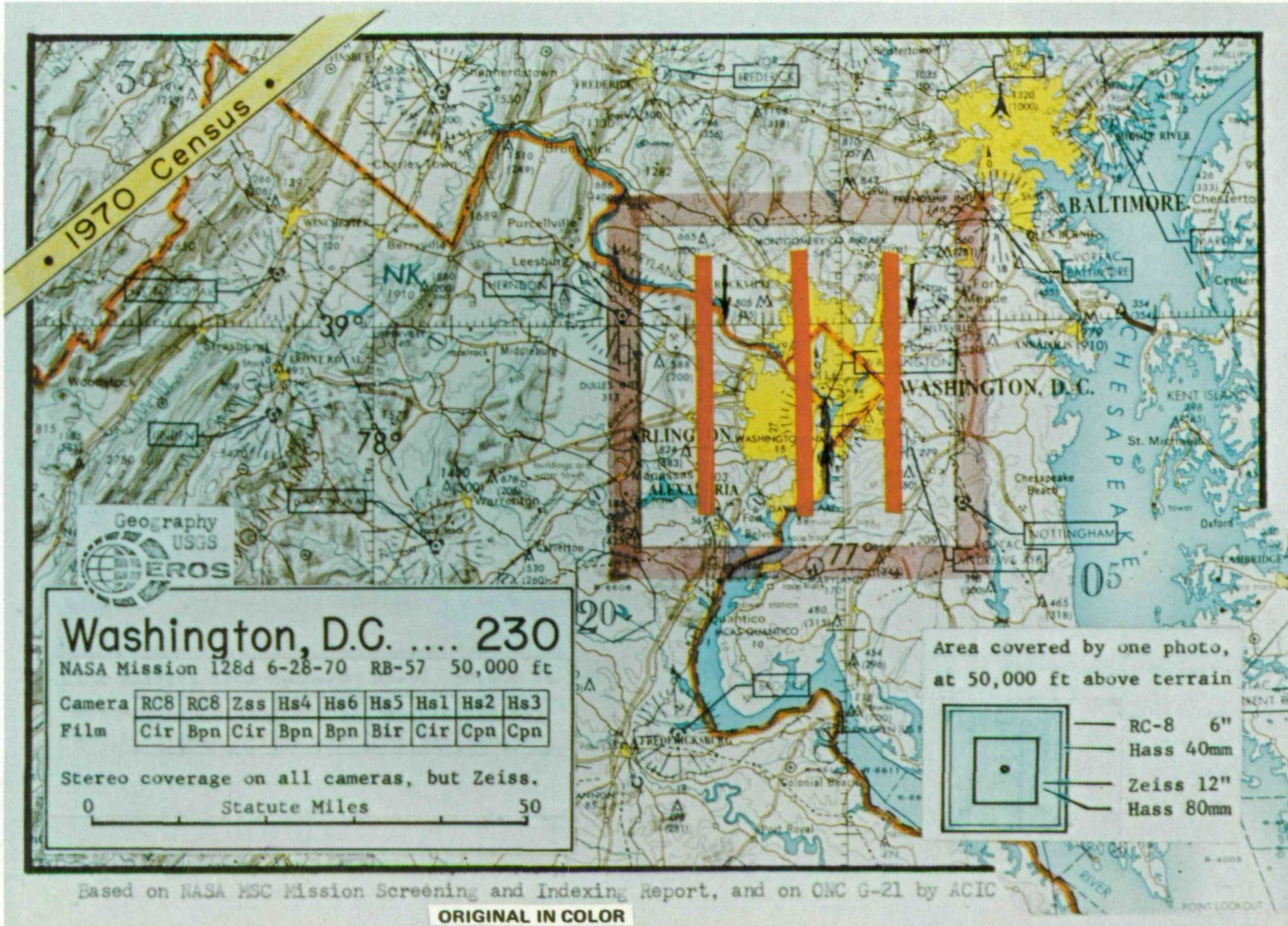

Plate 1.–Map showing flight lines and sensor coverage area, mission 128, Washington, D.C.

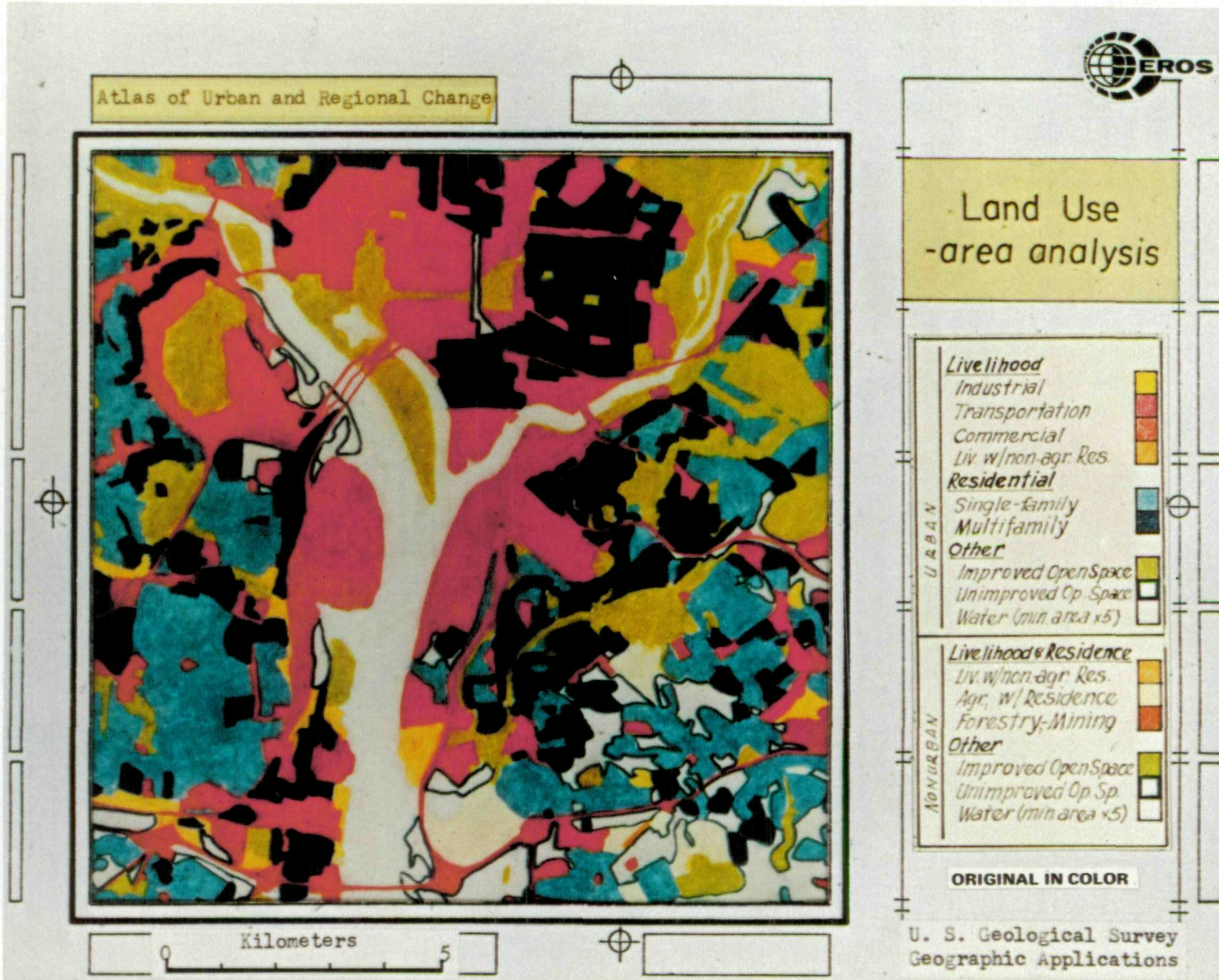

Plate 2.–Atlas of Urban and Regional Change, simulated page with land use interpretation compiled over the color infrared photograph.